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Executive Registry
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DEPARTMENT OF THE NAVY
NAVAL INTELLIGENCE COMMAND
4600 SILVER HILL ROAD
WASHINGTON, D.C. 20389

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From: Commander, Naval Intelligence Command
To: Deputy to the Director of Central Intelligence for Resource Management

Subj: Exceptional Intelligence Analyst Program

Ref: (a) DDCI ltr of 4 Jan 1980

Encl: (1) F. Warren Garmon's Academic Curriculum
(2) Engineering Experiment Station Work/Study Synopsis

1. Mr. F. Warren Garmon, a civilian employee of NISC, participated in the DCI Exceptional Intelligence Analyst Program during the period 1980-82. This letter provides an evaluation of Mr. Garmon's research program as requested by reference (a).

2. Mr. Garmon's efforts are expected to have significant, long-lasting value to the Navy. The education and experience he gained during the past two years is expected to pay great dividends at NISC in terms of increased productivity.

3. Mr. Garmon simultaneously attended Georgia Institute of Technology earning a Masters Degree in Electrical Engineering and worked at the Institute's Engineering Experiment Station (EES). The specifics of his study were determined by mutual consent of Mr. Garmon, Georgia Tech and NISC. Enclosure (1) details Mr. Garmon's curriculum, while enclosure (2) lists the work/study projects at the EES.

4. I strongly support the continuance of the Exceptional Intelligence Analyst Program. It is an excellent endeavor.

Chauncey Hoffman
CHAUNCEY HOFFMAN

Not referred to OSD - On file release instructions apply.

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F. WARREN GARMON'S ACADEMIC CURRICULUM

Mr. Garmon was awarded a Master of Science Degree in Electrical Engineering on 12 June 1982. His Grade Point Ratio (GPR) was 3.5 of 4.0. The following courses were taken during the period September 1980 to June 1982:

Course	Description	Grade
EE 4751	LASER THEORY AND APPLICATIONS: Principles, types, and applications of lasers.	A
EE 4803	RADAR ENGINEERING: Radar equation; CW, FM, MTI, Pulse Doppler and tracking radar; transmitters, antennas, and receivers; detection, propagation, clutter, interference; system engineering and design.	A
EE 6251	APPLIED ELECTROMAGNETICS: Advanced EM theory, discrete and continuous wave equation solutions, analysis, synthesis, and boundary value problems.	B
EE 6252	MICROWAVES: Field analysis of guided waves, equivalent-circuit theory for microwave systems, broadband impedance matching, passive microwave devices, microwave cavities, periodic structures and filters.	B
EE 6253	ANTENNAS: Classical antenna theory, array analysis and synthesis, EM characterization, and design of several antenna types, antenna measurements.	B
EE 6301	ELECTROOPTICS: Electrooptics with emphasis on lasers and modern optics, Gaussian beams, laser theory and types, modelocking, Q-switching, harmonic generation, parametric oscillation, and light modulation.	A
EE 6451	ELECTRICAL PROPERTIES OF MATERIALS: Basis of quantum mechanical formulism and modeling	A

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to serve as an introduction to the modern study of electrical properties of materials.

EE 6542	MAGNETIC AND DIELECTRICS PROPERTIES OF MATERIALS	Dielectries, piezo-and ferroelectrics and their application to electromechanical devices, quantum magnetism, magnetic interactions, domains, resonance and devices.	B
EE 6453	SOLID STATE ELECTRONIC DEVICES:	Study of charge and energy transport in semiconductors with applications in pn junction, interface and thin film, optoelectronic and bulk-effect devices.	B
EE 8340	FIBER OPTICS:	State-of-the-art material related to the fabrication, measurement and use of optical fibers, development of the theory of dielectric waveguides.	A
EE 8501	MODERN MAGNETIC MATERIALS AND DEVICES:	Operation and design of magnetic memories and microwave devices, crystal structure chemical composition, properties of ferrites, garnets and orthoferrites.	A
GEOS 4300	INTRODUCTION TO PHYSICAL AND CHEMICAL OCEANOGRAPHY:	Ocean geometry, physical properties of sea water, water movements and energy fluxes, sediments, marine geochemistry, geophysics and tectonics.	B
GEOS 4650	INTRODUCTION TO ATMOSPHERIC SCIENCES:	Atmospheric physics, chemistry, and dynamics.	A
GEOS 6300	PRINCIPLES OF PHYSICAL OCEANOGRAPHY:	Temperature, salinity, and density in the oceans, dynamics of ocean currents, theory of ocean waves.	B
GEOS 6764	OCEAN ACOUSTICS:	Propagation of sound waves in the ocean, stress-strain relationships, ray theory, shallow and deep water, irregularities and boundaries, sonar arrays.	AUDIT
GEOS 6830	PHYSICAL METEOROLOGY:	Principles of atmospheric physical processes, effects of atmosphere on radiation.	B

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GEOS 6811	DYNAMIC METEOROLOGY: Scale analysis, equations of motion, equilibrium motion, circulation, vorticity, divergence, waves, hydrodynamic and baroclinic instability.	B
GEOS 8123	GEOPHYSICAL FLUIDS: Properties of fluid mechanics, kinematics, balance laws, constitutive equations, Navier-Stokes fluids, potential flows, approximate solutions, boundary-layer theory.	A

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ENGINEERING EXPERIMENT STATION WORK/STUDY SYNOPSIS

I. Mr. Garmon's project at the Engineering Experiment Station (EES) included hands-on experience in radar detection modeling and familiarity with the research programs that utilized these models. Some of these models and related programs are summarized below.

A. SPHERICAL EARTH PHYSICAL OPTICS (SEPO) MODEL

SEPO is a detailed physical optics model which calculates the radar cross section (RCS) of targets above the surface of the ocean. The algorithm, which accounts for multipath and curved earth geometry, performs a numerical integration of the incident field over the target surface in computing the radar return. SEPO has primarily been used as an analysis tool and as a basis for generating TWEAK target models.

B. TWEAK TARGET MODEL

The TWEAK target model is a physical optics model, but specific targets are modeled as a collection of simplified target configurations for which the target cross sections are known. This permits a closed form solution for the radar return from each section. The total return is computed as the incoherent sum of the returns from the individual subtargets. This is equivalent to assuming phase independence between segments -- an assumption which has proved in practice to provide excellent results. TWEAK is a complete detectability model comprising target, sea clutter, and probability of detection algorithms. The sea clutter model has both theoretical and empirical bases and computes the RCS per unit area of a fully arisen sea in the radar cell occupied by the target. The Probability of Detection (PD) model assumes that the signal processor consists of a Plan Position Indicator (PPI) display monitored by an operator. This is the configuration of most

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surveillance radars and also represents a worst-case PD condition, as a human can operate with a lower effective threshold setting than an automatic detector with a constant false alarm rate. The model calcultes the PD based on the signal-to-background ratio of the backscattered signal.

C. RADAR DETECTION MODELS

EES has been involved in the detection of targets in clutter and in measuring/modeling the forward and backscatter characteristics of surfaces and targets for the past ten years. A number of models have been developed including a target model, a clutter model and a probability of detection model.

1. THE TARGET MODEL

Targets are modeled as a collection of simple geometric shapes (flat plates, cylinders, spheres, cone frusta), whose individual cross sections are calculated using a physical optics approximation. A propagation factor is calculated to account for multipath so that the effective RCS of each scatterer is a function of the wavelength, surface roughness of the sea, incidence angle, and height of the scatterer. The returns from the scatterers are added, where the phase relationship between the scatterers is correctly accounted for, and total effective cross section is calculated.

2. THE CLUTTER MODEL

The sea clutter model employed is a combination analytical and empirical model designed to provide an accurate estimate of σ^o, clutter cross section per unit area, over a frequency range of 3-18 GHz at incidenc angle from grazing to above 10 degrees. Dependence on wave height, wind speed, wind direction, incidence angle, radar frequency, and polarization are included.

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3. THE PROBABILITY OF DETECTION MODEL

The probability of detection model uses calculated values of clutter and target received power and radar signal processor parameters to calculate a probability of detection (i.e., the probability that a target blip will appear on the display). Target and clutter are assumed to be log normal distributed with median values determined by the models and with variances which have been observed from data. Receiver noise power is presumed Rayleigh distributed and is calculated from the IF bandwidth and noise figure.

D. TARGET RCS MODEL

A current model that incorporates portions of the previously described models is the target RCS model. One can begin with ship tank, aircraft, or other target plans and drawings and end with RCS predictions of any of these targets. Recent work indicates that the model is a useful tool in applying RCS reduction techniques to determine how much the RCS can be minimized.

The most recent model configuration performs basic computations and assigns an amplitude and phase to the radar wave scattered from simple geometric shapes. These simple shapes (flat plates, cylinders, truncated cones, dihedrals, trihedrals, and spheroids) were chosen because most target scatterers can be described analytically. Thus, the computer model requires a mathematical description of the elemental scatterers of the target.

E. BUOYANT CABLE ANTENNA (BCA) MODELING AND MEASUREMENTS PROGRAM

A second area in which Mr. Garmon was involved is the development of a floatation model for a buoyant cable antenna. Considered in the model are the effects of cable length, tow speed, hydrodynamic forces, cable bending movements, buoyancy, and gravity. The resulting model is a fourth order partial differential

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equation which is solved by a finite difference computer formulation. One of the problems in the solution is to determine the hydrodynamic forces on each section of the cable. The solution assumes multiple Gerstner waves whose orbital velocities can be solved as a function of position. It was in the ocean description that Mr. Garmon was most deeply involved, because of the oceanographic background he received as part of his Master's degree program.

The flotation model provides the appropriate statistics to a Monte Carlo BCA RCS model. That model produces a distribution of RCS by random selection of appropriate parameters defined in the flotation model. The RCS statistics produced were compared to data measured in a recent field operation.

F. SHIP AND TANK RCS PREDICTION PROGRAM

Current programs include efforts to predict RCS of ships and tanks. In addition, computer simulations of missile/ship, missile/tank engagement scenarios are being run to ascertain aim point wander effects, if any.

G. INVERSE SYNTHETIC APERTURE RADAR (ISAR) PROGRAM

Classical synthetic aperture radar (SAR) analysis focuses on the use of radar platform motion to provide enhanced cross range resolution of stationary targets. A recent technique to provide radar cross range resolution is ISAR, which depends on target motion to provide differential Doppler. As an example, if a radar views of a ship from bow-on, any pitch motion will separate the return in Doppler as a function of height, with scatterers at the waterline having a minimum radial velocity, and therefore Doppler, and scatterers highest on the masts having maximum Doppler. Thus, a range-cross range image can be produced which resembles the broadside profile of the ship. Other aspects and roll/pitch/yaw combinations provide other apparent image planes.

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Mr. Garmon was involved in upgrades of an ISAR model which combined a sophisticated target RCS model with ship motion and radar processing algorithms to produce ISAR images. These upgrades account for the smearing of the image due to pulse compression range sidelobes and target motion during image integration.

H. MAST RCS PREDICTION PROGRAM

The RCS of submarine masts can be accurately predicted by modeling techniques. The detectability of a modified mast was determined and compared to the probability of detection of the unmodified configuration.

II. In addition to the modeling projects described above, Mr. Garmon also participated in studies relating to synthetic and real aperture sidelooking radar.

A. REAL APERTURE SIDELOOKING RADAR

Predetermined radar parameters were used to determine the performance of the radar system in terms of area coverage, signal-to-noise and signal-to-clutter ratios for a standard RCS target under typical environmental conditions. These ratios are compared to those normally required for visual detection from a radar CRT display. (See attachment 1.)

B. SYNTHETIC APERTURE RADAR

A review was performed of the operation and performance capabilities of synthetic aperture radars including a description of the formulation of the received signals and how they are used to derive the azimuthal resolution limits for the focused and unfocused cases. The desirability of having approximtely equal azimuth and range resolution for imaging radars was also presented. Various processing techniques were analyzed including optical and digital processing for focused SAR. (See attachment 2.)

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